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BULLETIN No. 1

1927

DRY-ROT IN WOOD

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DRY-ROT IN WOOD

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PREFATORY NOTE

THAT form of decay popularly known as "dry-rot," caused by various timber-destroying fungi, is an evil the disastrous effects of which are only too familiar. The term "dry-rot," though it aptly describes the brittle and dry appearance of the timber after attack, is not so fitting a description during an attack, for the presence of a certain amount of moisture is necessary to the growth of the fungi causing the decay: indeed, one of these fungi can itself produce, in its life-processes, enough water to render the wood damp.

In spite of the familiarity of dry-rot, the number of cases still arising in which decay has been invited by faulty building construction and improper use of the timber, or where inadequate remedies are applied, is ample evidence of the need for wide dissemination of all information which may assist towards reducing what is the cause not only of a very large wastage but of many serious accidents.

The purposes of this Bulletin are to present in a simple and practical form the sum of existing knowledge of the subject, to assist recognition of the signs of the disease, and to provide authoritative information concerning its prevention and remedy. The subject falls naturally into three groups, namely: (1) the identification of the fungi causing dry-rot and the investigation of the conditions necessary for their existence; (2) the detection of and remedy for dry-rot; and (3) the precautions to be taken in designing buildings and in the use of the timber therein, to prevent outbreaks of dry-rot. The Bulletin therefore deals, in turn, with each of the above groups and has been written by specialists respectively in each aspect of the subject.

Part I has been written by Professor Percy Groom, D.Sc., F.R.S., Professor of the Technology of Woods and Fibres, Imperial College of Science and Technology, London; Part II has been contributed by H.M. Office of Works, with assistance, as regards the section on preservatives, from Professor Groom and the Forest Products Research Laboratory; while Part III has been contributed by the Building Research Station of the Department.

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R. S. PEARSON,
Director of Forest Products Research.

FOREST PRODUCTS RESEARCH LABORATORY,
Princes Risborough,
Bucks.

November, 1927.

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substance, but contains countless minute cavities of various shapes. The wood-substance forming the solid framework is hygroscopic, becoming moister or drier in conformity with the surrounding air. Whereas many of the cavities of the wood in the living tree or in freshly felled timber contain liquid water, the cavities of the wood in houses contain no water in the liquid state, unless the wood be sodden through accidental access of water; instead, these cavities contain air and occasionally other substances to be mentioned later. The wood-substances, which for the most part form the food-supply available to fungi, are mainly composed of material easily converted into sugars, and are highly nutritive to those animals ("worm") and plants (e.g. fungi causing dry-rot) that can affect this conversion by digestion.

Structure and Growth of Fungi

Fungi causing dry-rot consist of many branching, hollow, thread-shaped tubes, which grow mainly in length. The tubes may be loosely arranged and mould-like, or crowded to produce fluffy cushions; or by their close interweaving they can give rise to denser sheets, strings or bosses, or to fruit-bodies which assume forms varying from that of a mushroom to that of a skin or pancake. Each fruit-body produces countless microscopic, more or less rounded, spores which act as infecting germs. Each spore is often capable of producing a complete fungus plant, but in some cases the co-operation of two spores is required for this purpose. The spores of some species (e.g. *Merulius lacrymans*) when dried can live for years.

There are many kinds of fungi (see Schedule, pp. 6 and 7) that cause dry-rot in houses, but according to their mode of growth they may be arranged into two biological groups. In one group the fungus grows largely or exclusively inside the wood, until it produces a fruit-body at the surface; here the advance of the decay is relatively slow and eradication from a house is generally simple. In the other group the fungus not only grows inside the wood, but also swiftly advances over its surface, and may indeed pass on to other surfaces; here the advance of the rot is widespread and more rapid, and eradication is apt to be more difficult and costly.

When dry-rot is caused by a fungus belonging to the first group, an infected beam or joist may appear on the outside to be quite sound—for here the fungus keeps at some distance from the outside—and the first evidence of decay may be breakage or the production of a fruit-body at the surface. Prior to the appearance of a fruit-body, the cure may be quite simple and consist of the mere removal of the infected wood.

Much more serious are apt to be the cases caused by fungi of the second group, to which belongs the malignant *Merulius lacrymans* (Figs. 1, 2, 4–8), the species responsible for the gravest of all kinds of dry-rot. When a spore (or possibly a group of spores) germinates on and attacks a piece of wood, some of the thread-like tubes emitted penetrate the wood, while others grow on the surface; thereafter those fungal tubes inside advance slowly, while those outside advance at a much greater pace and at intervals emit threads which delve into the wood. Thus *Merulius*, outside the wood, grows like a strawberry plant, which creeps over the soil, into which it sends roots at intervals. The fungal threads outside the wood produce growths whose form depends on the amount of moisture present; when this is abundant, the wood is clothed with beautiful snowy white cushions (occasionally with yellow patches), but when the wood and air are drier the fungal threads interweave to form dense flat skins (white or lilac), nets, or long strings. *Merulius* can advance on to materials other than wood, and can produce its various growths on stone, brick, or steel; while its strings, sometimes attaining the thickness of a lead pencil and a

length of many yards, can burrow through the mortar of walls, pass from one room or one storey to another, and may permeate a house or even run through a whole row of houses. But the fact that the fungi of this group cannot, even with the necessary moisture, feed solely upon stones, bricks or mortar, is of the utmost practical importance in connexion with the eradication of dry-rot. Owing to the distance this fungus can travel during its rapid growth, and for other reasons, the eradication of dry-rot caused by *Merulius lacrymans* is apt to be very costly and may be a matter of grave difficulty.

Fungi which, like *Merulius*, grow over the surface of wood are responsible for *contagious* dry-rot; but fungi causing serious dry-rot are also *infectious* organisms, as their spores or germs are carried through the air to distant places. In some cases an individual thread-like tube of the fungus, even when this is very young and minute, may produce countless spores, for instance, by breaking up into pieces which separate and function as germs. Frequently the fungal tubes outside the wood, if allowed to dry slowly, give rise to myriads of spores, so that before the tubes themselves die from lack of water they produce a new centre of infection. The most obvious propagation of spores takes place, however, in the fruit-bodies, which are of various characteristic shapes and colours. *Merulius* usually produces a flat fruit-body, in form more or less like an irregular pancake. Its exposed face has a snowy-white margin, but elsewhere is rust-coloured or rusty-brown and usually displays a labyrinth-like complex of ridges and furrows; when growing on vertical surfaces this fruit-body may assume more or less incompletely the form of a bracket with the rusty spore-producing face directed downwards (Fig. 4). Another important kind of fungus, *Coniophora puteana* (*cerebella*) (Fig. 3), resembles *Merulius*, not only in growing over the surface of the wood, producing strings (which are thinner and very often soon become deep brown), but also in having a flat fruit-body of varied outline; this however, differs from that of *Merulius* in possessing a spore-producing surface which is raised into numerous little pimples and is often brownish or the colour of doe-skin. The fruit-bodies of both types are easily visible, and indeed may attain a diameter of one or more feet. The fertile surface violently shoots off myriads of spores; in fact, it has been estimated that a square yard of *Merulius* fruit continues to throw off in each minute something approaching fifty million spores. Each appropriate pair of spores* can produce a little fungus which can break up within a few days into thousands of spores.

When, as is often the case, fruit-bodies are lacking, identification of the fungus present is more difficult, and is accomplished either by causing the fungus to produce its characteristic fruit-body or by noting, often with the aid of the microscope, certain features in the structure and behaviour of the non-fruiting fungus.

Conditions of Development

Fortunately, there are many conditions that determine whether a piece of wood will be attacked by a fungus in contact with it, and these exercise considerable restraint upon development. An understanding of these conditions supplies valuable guidance as to the steps that should be taken to guard wood against decay.

The first condition necessary for active growth is a *supply of air* which contains the oxygen needed for respiration. Thus, in the process of respiration, dry-rot is necessarily accompanied by a fouling of the air by carbonic acid, and by the production of water. *Merulius lacrymans* in active growth produces so much water that this may be seen hanging to the ends of the fungal threads, and has consequently given to the fungus its

* It has, however, to be pointed out that, often at least, the spores from the fruit-body of *Merulius lacrymans* grown in this country cannot be induced to germinate.

specific name of "weeping." Moreover, the water thus produced can render the wood thoroughly moist.

The second condition of growth is an adequate *supply of water*. This is needed because: (i) water enters largely into the composition of the fungus; (ii) all substances entering, travelling through, or leaving the fungus can do so only when dissolved in water; (iii) water must be supplied if wood is to be chemically so changed as to yield digestible food, sugar; (iv) a spore will germinate on and attack wood only if it is moist, though no liquid water need be present nor need the air be saturated. It is, however, equally true that wood-attacking fungi cannot grow in wood that contains an excess of water; for from water-logged wood the air has been largely expelled, with the consequence that any fungus inside it will suffer from a restricted supply of oxygen—and possibly from an accumulation of carbonic acid that is poisonous to it—and will be suffocated.

The precise amount of water demanded by different species of fungi causing dry-rot varies. Some species, like *Coniophora puteana* (*cerebella*), demand much, and are accordingly found only in thoroughly damp places in the house; these species are readily brought to passivity by ventilation or other means of inhibiting damp. Some other species, like *Merulius lacrymans*, when once in full vigour of growth, can attack very dry wood because they have the power, already explained, of manufacturing much water; their growth cannot, therefore, be arrested by ordinary ventilaton. It is true that the exposed, loose, fluffy or silky threads of even *Merulius lacrymans* are killed by exposure for comparatively few minutes to a current of dry air, but the denser skins resist longer and the thick strings keep death at bay for a considerable time, while within wood that is well dried by exposure to direct sunlight in a dry room, this fungus may remain alive at least for many months. Even in some species that when active require much moisture, the fungal threads inside the wood are not readily killed; for instance, a species not uncommon in houses, *Lenzites saepiaria*, belonging to the type that exists almost solely inside wood and does not grow unless the wood is thoroughly moist, is yet very resistant to death by desiccation. These facts have an important practical bearing, since they show that infected wood does not become harmless when it is dried; for, when once more supplied with water, the fungus inside may waken to activity and emit from the surface of the wood either a fruit-body or many white fungal threads.

A third factor that decides whether or no a piece of wood will decay is *temperature*. Fungi causing dry-rot are active, and grow only within a certain range of temperature peculiar to the species, so that when wood is too hot or too cold for the particular kind of fungus, no decay can be caused by it.* Every part of a building, even the cellar, is at times warm enough for the wood to be attacked by dry-rot; it occurs all too commonly in the wood used as the insulating material in cold stores, even though the temperature there may be below freezing point for months. At the same time, there are few places in a house so hot as to exclude dry-rot. Yet heat, wet or dry, can be utilised to sterilise wood or brickwork: when applied at temperatures far below the boiling point of water, but above that at which growth ceases, it rapidly kills the fungus, and applied at boiling point, it kills the spores of fungi causing dry-rot. Cold, on the other hand, has a less powerful lethal action, at least in familiar cases. *Merulius lacrymans* and its spores can remain alive after exposure for months to temperatures below the freezing point of water.

* As a matter of interest, mention may be made of the fact that *Merulius lacrymans* ceases to grow at a temperature several degrees below that of the human blood, so that it is highly improbable that the fungus can grow inside human beings, and thus as a parasite directly cause disease.

So far, it has been shown that dry-rot will develop in a piece of wood only if certain conditions, including appropriate supplies of air, water and heat, are satisfied; but the most obvious condition required is the *presence* on the wood *of a fungus* capable of inducing it. The fungus, as already explained, in some cases reaches a sound piece of wood by the growth of fungal tubes advancing from infected material, but in other cases it arrives in the form of a microscopic spore. The conditions leading to infection in these two cases are different. If, for example, we place a number of spores from the fruit-body of *Merulius lacrymans* on a piece of moist sound wood, the spores will not attack the wood; if we do the same with spores of *Coniophora puteana* (*cerebella*), they will emit tubes that penetrate the wood and set up decay; yet the spores of *Merulius* may germinate on and attack wood* that has been previously assailed by *Coniophora*. From this point of view, therefore, fungi causing dry-rot may be divided into classes according as their spores will or will not attack sound wood. It is clear that if infected wood be used in the construction of a house, even if the fungus inside be dead, it represents wood more vulnerable to attack.

In any diagnosis of suspected trouble from dry-rot, the precise nature of the *food material* upon which fungi found in a house feed is of importance in deciding whether or not these fungi are liable to induce dry-rot. In every building will be found fungi ranging from familiar moulds to larger forms with mushroom-like fruit-bodies, but only some of these do serious harm to the woodwork. The blue discoloration of the sapwood of the softwoods used in the construction of houses is caused by a species of fungus that feeds almost or quite exclusively upon the contents (starch, sugar, oil and albuminous matter) of the cavities in the sapwood and leaves the wood-substance nearly intact. Some other fungi, for instance in cellars, feed solely upon the soil. Fungi causing dry-rot, on the contrary, feed upon the wood-substance itself, and thus destroy the timber. But they cannot attack and digest all kinds of wood with equal facility. In the first place, sapwood is more readily attacked and more perishable than the heartwood of the same timber, in those species which show a clear distinction in colour between sapwood and heartwood, as is the case with oak, red deal and pitch pine. It is necessary to emphasise this statement, as it is sometimes alleged that the sapwood of the most important building timber in Europe, red deal, is quite as durable as the heartwood, the well-preserved sapwood of this timber in old beams, joists and rafters being pointed to in support of the contention. The fact, of course, is that the sapwood, so long as it is dry, resists decay, but when moistened it rots much more readily than the heartwood. Again, some kinds of fungi can set up dry-rot only in certain kinds of timbers, softwoods (i.e. coniferous timbers) for instance; whereas other kinds, including *Merulius lacrymans*, can destroy timbers ranging from softwoods to such durable hardwoods as oak, teak and mahogany.

Very important in facilitating the spread of dry-rot is the fact that the fungi responsible can live at the expense of organic materials other than wood. They can feed on paper, potatoes, jellies containing extracts of fruits or meats, and, above all, at least some of them can grow on moist garden soil. The result is that a house can become infected with *Merulius lacrymans* through the agency of the soil. Finally, although when the strings of this fungus are severed from connexion with the woodwork, they have no food available in the wall (except inconsiderable quantities of fibrous material in the mortar or any organic solution from the soil where the damp courses do not intervene), the solid parts and the liquid contents of the strings themselves represent a certain amount of food material; at the expense of this the strings, when moistened, can put forth fungal threads that may emerge from the wall and infect the adjoining wood.

* This is true of *Merulius lacrymans* grown in Germany, but certainly not universally true when the fungus is English in origin.

SCHEDULE OF FUNGI CAUSING DRY-ROT

	Strings on the surface of wood.	Other growths on the surface of wood.	Fruit-bodies.*	Demands for water and other comments.
Merulius lacrymans (*domesticus*).	Strings, white to grey, sometimes as thick as a lead pencil, becoming *brittle* when dried.	Growth in the form of dense sheets (white to lilac) or white cottony or smooth cushions, which *subsequently* may acquire secondary yellow patches.	Usually shaped like pancakes or brackets. Fertile surface yellow to brown with usually *labyrinth-like ridges and furrows*, but with a white margin.	Not demanding much moisture. Rot thorough and causing cross-shakes.
Polyporus vaporarius (group).	Strings white, never as thick as a lead pencil, remaining *flexible* when dried.	White growths of various kinds that never show secondary discolorations.	Shaped like thin sheets, white in colour. Fertile surface showing numerous minute *pores*.	This is probably not one single fungus but a group, all demanding more water than the preceding, but varying in this respect and in the degree of rot caused.
Coniophora puteana (*cerebella*).	Strings slender, thread-like, very soon becoming reddish or deep brown or nearly black.	Only occasionally very thin skin-like growths.	Sheet-like in shape. Fertile surface yellow to olive brown, showing many minute *pimples*.	Demanding much moisture. Causing usually incomplete rot of wood (often without cross-shakes).
Paxillus panuoides (*Acheruntius*).	Very slender, yellow but eventually brownish yellow.	Other growths yellow to reddish-violet in colour.	Usually shell-like or fan-like in shape, stalkless, *fleshy* in texture. Fertile surface light yellow but eventually sienna, with *radiating gills*.	Demanding much moisture. Causing the attacked wood at first to assume a characteristic yellow colour.

	Strings on the surface of wood.	Other growths on the surface of wood.	Fruit-bodies.*	Demands for water and other comments.
Lenzites saepiaria and L. *abietina.*	Absent.	Occasionally sheets or cushions old gold or tan in colour. Often absent.	Emerging from cracks in the wood and varying in shape and size accordingly, *corky* in texture. Fertile surface showing yellow to umber *radiating gills.*	Demanding much moisture for growth, but the fungus inside the wood strongly resisting death by desiccation. Decay internal, with cross-shakes and cup-shakes. External wood apparently intact except for cracks.
Polyporus destructor.	Absent.	Absent.	Bracket - shaped, zoned internally (as seen when cut vertically), white to grey. Fertile under surface showing countless minute *pores,* white.	Apparently demands much moisture for growth. Decay internal.

* The fruit-bodies of these fungi are liable to exhibit considerable variations in their shapes and in the pattern of the fertile surface; here the most common and characteristic forms are indicated.

FIG. 1.—*Merulius lacrymans.* Cushion-like growth on shelves.

FIG. 2.—*Merulius lacrymans.* Part of spore-bearing stalactite-like surface of a plate-like fruit body on vertical wall.

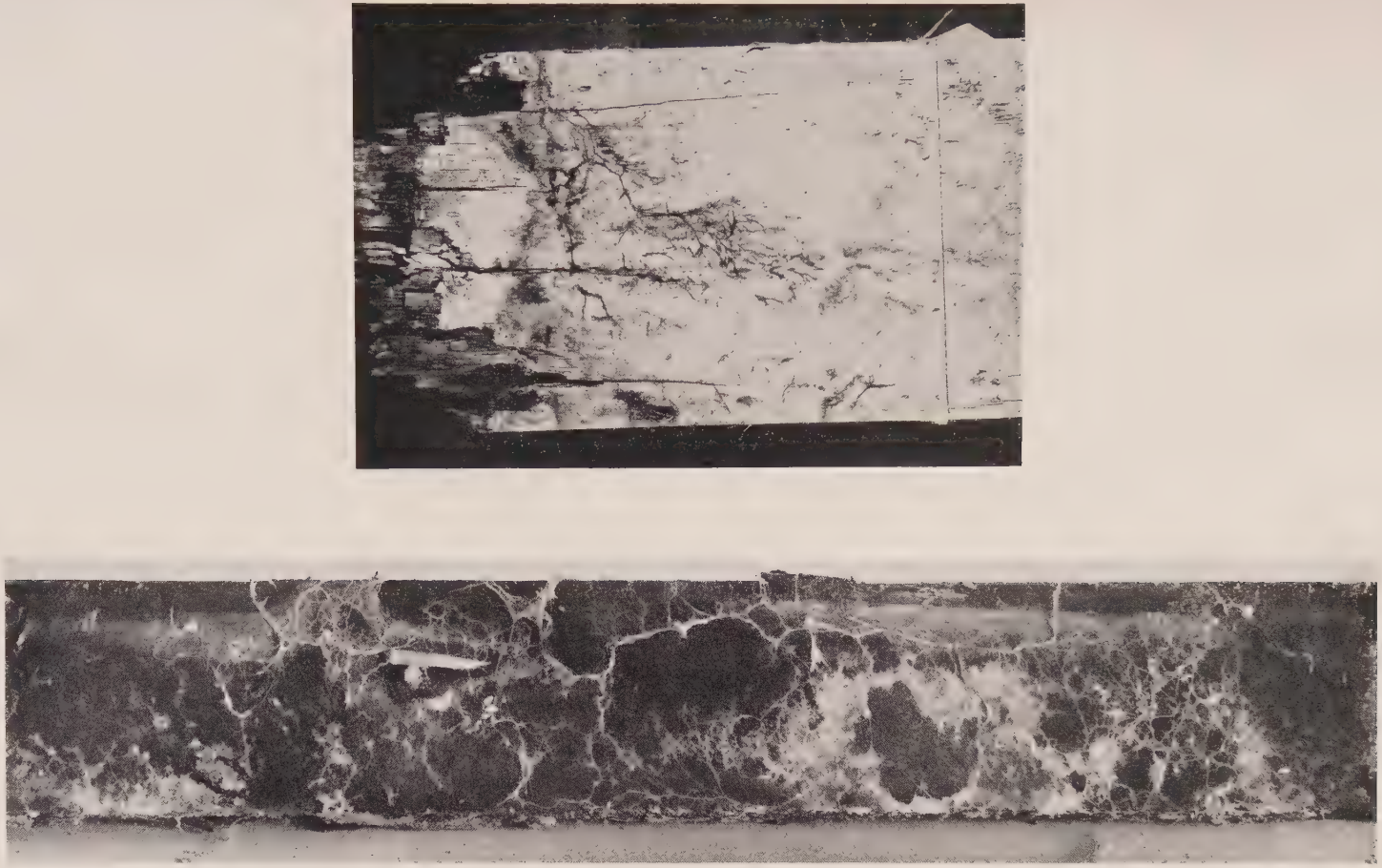


FIG. 3.—*Coniophora puteana* (*cerebella*). String-like growth over wood.

FIG. 4.—*Merulius lacrymans.* A bracket-like fruit body with stalactite-like spore-bearing surface: reduced.

FIG. 5.—*Merulius lacrymans.* Young cushion-like growth emerging from decaying wood.

FIG. 6.—*Merulius lacrymans.* Young plate-like fruit body showing labyrinth-like spore-bearing face (reduced).

FIG. 7.—*Merulius lacrymans.* Strands on oak beam.

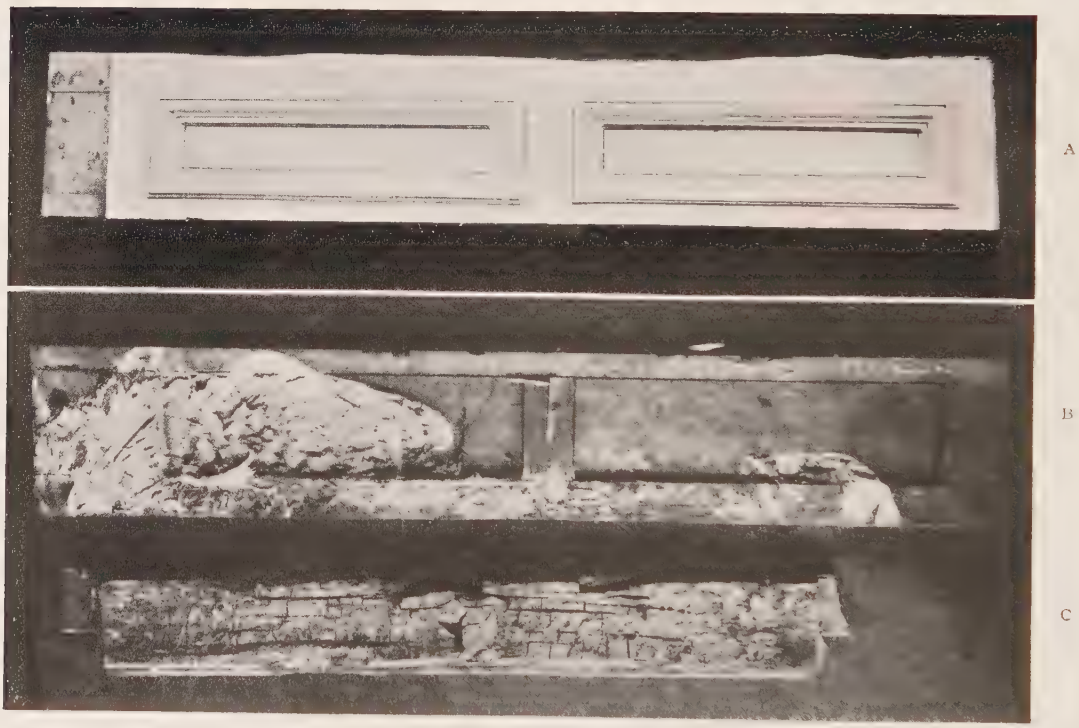


FIG. 8.—*Merulius lacrymans.* A. Front of panel attacked.
B. Back of same panel attacked.
C. Wood attacked showing cross-shakes.

PART II.—THE DETECTION AND PRACTICAL TREATMENT OF DRY-ROT

General

WHEN dry-rot has been discovered in a house, the first step to be taken is to determine, if necessary with the aid of technical experts, which of the many kinds of dry-rot is present; and the second step is to take the most economical action to eradicate it and to prevent its recrudescence.

The treatment in each case depends, in the first place, on the identity of the fungus causing the rot and on the conditions prevailing. If the fungus be one that grows only inside the wood, it may suffice merely to replace the infected piece by a sound piece. If, again, the fungus is one that attacks only softwoods, it may be simplest and cheapest to replace the softwood by a hardwood. And when the fungus attacking the wood is one that demands much moisture, in the simplest cases the drying and subsequent protection of the woodwork from damp (by ventilation and other means) constitute an adequate treatment; but in less simple cases this may have to be supplemented by antiseptic measures. Here a warning must be given. It is not safe to assume that only one kind of fungus is present and causing dry-rot; in numbers of cases several kinds are found simultaneously attacking one and the same piece of wood in a building.

The drastic treatment recommended for the eradication of dry-rot in these notes need only be adopted when the decay is due to one of the kinds of fungi that have the habits or growth of *Merulius lacrymans*. At the same time, less drastic and less expensive methods of treatment should be adopted only under expert advice and where the fungus responsible for decay and damage has been identified by a specialist as being of a less severe type than *Merulius lacrymans*.

Preliminary Investigations

The extent and nature of the preliminary investigation will depend upon the type of the building. When a building is of importance, either historically or architecturally, it may be advisable to prepare a report, illustrated by drawings and photographs, upon the positions in which the outbreak has occurred, and upon the extent of the decay. If the report shows that the attack of dry-rot is extensive and dangerous, it is advisable that samples of infected timber, especially that showing fungus, should be carefully selected and submitted for expert opinion. In the case of ordinary domestic buildings, a report will not usually be necessary, unless there should be a possibility of legal action, when records will doubtless be useful.

Signs of Decay

The external and visible signs of decay vary with each particular building, but some of the more general indications to be looked for are:—

(*a*) Lead flats and gutters in a roof become sunken and depressed, and after heavy rains may retain pools of water. The indications are that the boards and the bearers have become decayed;

(*b*) The rafters in a sloping roof are often attacked at their lower ends where they rest on the wall head. They become displaced, and tiles or slates may become broken, loose and "wavy" in appearance.

(*c*) Roof timbers and floor beams often rest upon another timber buried in the wall, known as a wall-plate or bond-timber, which is particularly liable to be attacked by dry-rot. The attack usually extends to the adjoining timbers, and, as a consequence, settlements occur which cause cracks in ceilings, uneven floor boards, and irregular roofs.

(*d*) Floor boards, if attacked, may give way under the weight of a person or a piece of furniture. Floors that are covered with linoleum should be completely uncovered where dry-rot is suspected, and the boards (together with the floor joists where they exist) should be inspected very thoroughly. The inspection should not be confined to one part of the room; timbers adjoining all the wall surfaces should be examined.

(*e*) Two sections of wood, joined by screws or nails, may come apart, thus indicating the possibility of dry-rot below the surface.

(*f*) In painted woodwork decay is usually indicated by the shrinking of the wood and the formation of cracks parallel to the grain, due to the desiccation of timber and the loss of its tensile and compression strength.

(*g*) Apart from the visible signs of decay, the presence of dry-rot fungus is often indicated by a musty, damp smell which, if the growth be vigorous, may become very offensive.

Tests for Determining Soundness of Timber

Practical tests for determining whether timber is sound or not are:—

(*a*) Drive into it a sharp-pointed tool about $\frac{1}{4}$ in. diameter. If the timber is rotten, the tool will enter easily and can be withdrawn without effort; if sound, the pointed end will meet with resistance and the wood fibres will grip it, so that some effort is required to withdraw.

(*b*) Striking the timber with a hammer. If in good condition it will give out a ringing note; if decayed, the sound will appear dead and dull.

(*c*) In timbers of large size drill small holes with an auger. The shavings can be withdrawn about every inch in depth, to be put on one side and examined for evidence of fungus. Cavities in the heart of a timber can be detected by means of this test.

Measures for Preserving the Safety of the Structure

Where dry-rot is found to have caused extensive decay in the timbers of a building, it may be necessary, before proceeding with the removal of decayed timber and with the work of repair, to provide temporary support to floor beams, roofs and walls. This support must, of course, be designed and erected to meet individual cases, and no specific directions can be given in this memorandum.

Repairs to Historic Buildings

When carrying out the repairs to a building of historic importance, all carved or moulded work, whether in roofs or wall decorations, should, as far as possible, be retained. This may necessitate the adoption of special methods of construction or repair, and greater care will also have to be taken in the preservative treatment, so that any new timber, introduced during the repairs, may not be contaminated by contact with the old.

Determination of the Extent of Infection

During the process of removal, it is important to follow up all visible signs of the fungus. As pointed out on page 3, the fungus may be found penetrating through the joints of brick walls and even between successive layers of plaster. It may extend for considerable distances, from one part of the building to another. Cases have, in fact, been known where the fungus has travelled from a ground floor between the layers of plaster, up to the first floor, and has there attacked the timbers. It is a common experience to find the fungus spreading from floors to skirtings, door frames and architraves. Another instance which may be quoted as somewhat unusual in character was where the fungus travelled (in the form of a string, or piece of cord) along the flange of a rolled steel joist for a distance of more than 10 feet. It had its origin in timber near one end of the joist, and was eventually able to attack the timber at the other end, although there was no timber in contact with the steel upon which the fungus could feed.

It is thus necessary to stress the importance of making the most thorough inspection, in all cases, to discover all seats of infection and the necessity for the complete removal of all affected timber ; otherwise, there will be great danger of another attack at a subsequent date.

Removal and Burning of Decayed Timber

All decayed or unsound timber must be removed, including that which appears sound but is part of a decayed piece or is contiguous to a piece that is affected. This wood should not be left inside the building, but should immediately be removed to the open air and burnt.

Defects in Structure that may have caused Decay

After all the decayed timber has been removed, a very careful examination should be made to determine whether there are any defects in the structure, or in the mode of construction, that are giving rise to conditions conducive to the development of dry-rot. Such conditions are :—

(*a*) That moisture is gaining access in some manner.

(*b*) That there is lack of free circulation of air around the timber.

Either, or both, of these conditions, if they exist, must be remedied before proceeding with the replacement : the first either by making good the structural defect or waterproofing the affected surfaces, and the second by providing for a free circulation of air

around the timber. The importance of ensuring the effectual remedy of any such defects cannot be overstated, as the success of the remedial measures depends very largely upon this.

There is some evidence indicating that an outbreak of dry-rot may commence after leaks in a lead flat, or other type of roof, have been repaired. The once saturated timber will dry, but the fungus, being thus deprived of this source of moisture, may itself begin to produce the moisture necessary for its development and grow vigorously. The evidence is not yet conclusive, but sufficient information has been collected to justify the assumption that such an outbreak is possible.

Old wood shavings which may be left, either accidentally or intentionally, under floors or elsewhere, are suspected of facilitating attacks of dry-rot. They should, of course be removed.

Another possible source of infection is from earth, which may have in it the remains of decayed trees or other vegetation. The spores in the ground of fungi causing dry-rot will develop, and the fungus will extend around or through brick walls which do not possess an effective damp course. The fungus, when coming in contact with timber in window- or door-frames, will attack it and cause decay.

Sterilisation Measures

After having removed all decayed timber and remedied defects in the structure, it will be necessary to clean and sterilise all surrounding surfaces. Brickwork, concrete and other surfaces to which heat may be safely applied may be sterilised by heat treatment. All unaffected timber that is retained should be sterilised either with magnesium silicofluoride solution or with one of the heavy tar oil preservatives. It is also advisable that all new timber used for repair should be treated with a preservative before being fixed: if, however, any of the surfaces or joints are cut or broken during or after fixing, they should be given separate treatment.

If dry-rot fungus is suspected of originating in the soil surrounding the building, it will be necessary to sterilise the earth in some manner:—

(*a*) The soil itself may be sterilised by mixing it with a quantity of quicklime, or a suitable antiseptic such as creosote.

(*b*) If the soil is entirely removed the external surface of the wall should be coated with tar or creosote.

Sterilisation by Heat

As already mentioned, brickwork, concrete and other surfaces to which heat may be applied with safety can advantageously be treated by this method, particularly where there are indications that the thread of the fungus have penetrated into the heart of the wall. Normally a blow lamp can be employed. The heat should be applied evenly and slowly over the surface, until it reaches such a temperature as is uncomfortably high to the touch.

A more drastic method is to employ an oxyacetylene flame, which may be necessary in the case of very thick walls. A very high temperature up to 2,000° C. is obtained. This method should, therefore, be used with great caution, to avoid risk of fire. The flame should be swept lightly over the surface of the walls, and should not be allowed to concentrate for any length of time on one area.

Sterilisation by Preservatives

The precise kind of preservative to be used varies with the situation of the wood to be protected. Some wood preservatives are excluded from use, at least inside a house, by reason of their scent. Such is the case with creosote, and even with certain other less aromatic preservatives whose slight odour is still sufficient to taint fat (of bacon or butter), other food substances, and even cigars. Again, some preservatives are excluded from use by reason of the colour they impart. Finally, it may be noted that one fungicide may guard wood against one kind of fungus but not against others. As to the wood-preservative to be used in a particular case, if the advice of a technical expert be not sought, it is wisest to choose a fungicide that has passed the test of years and has proved its prolonged efficiency in a place where dry-rot has actually occurred.

Among the number of kinds of wood-preservatives used or advertised as providing adequate protection against dry-rot in houses, some are good, some indifferent, and others worthless. Confidence should not be placed in the following :—Blue or green vitriols (sulphates of copper and iron), common (table or rock) salt, and lime water, which represent a series of decreasing fungicidal power. Copper sulphate in particular also attacks iron, and in its commercial form in presence of iron can vigorously attack wood. Zinc chloride, sodium fluoride and magnesium silicofluoride (acid) in proper concentrations are more useful, but when too strong the first named itself attacks wood, while the much more fungicidal acid silicofluoride attacks iron and glass. Corrosive sublimate is highly poisonous, not only to the fungi in question but also to human beings, and has only slight powers of penetrating wood ; yet under competent advice it may be used on occasion. It has one useful character, namely, that it is soluble in alcohol as well as in water. Opposed to these inorganic preservatives are organic ones, among which carbolic, acetic and salicylic acids, as well as formalin, may be excluded from use on account of their early evanescence. Here it may be mentioned that many disinfectants and antiseptics capable, even in extreme dilutions, of killing bacteria that cause human disease, are worthless, even in high concentrations, against fungi causing dry-rot ; it is of no use to wash a rotting floor with an antiseptic soap in the hope of checking decay. Valuable preservatives for use in houses are some that are mixtures of tar oils, especially coal tar oils. Finally, in particular cases, mixtures of sodium fluoride and dinitrophenol or sodium dinitrophenate may be profitably used.

Magnesium Silicofluoride

In cases where the use of a tar oil preservative is undesirable, either from the point of view of colour, odour, or danger of damage to surrounding work, a 5 per cent. solution of acid magnesium silicofluoride may be used, which is colourless and will not have any harmful effect. But the heavier tar oil preservatives (of which a considerable number are manufactured as proprietary liquids) are recommended for the treatment of all timbers wherever suitable, as they are likely to remain effective for a longer period than the silicofluoride.

The magnesium silicofluoride to be used is not the pure salt but the acid commercial salt, which is a white solid containing free acid. The solution (5 per cent.) is made by dissolving $\frac{1}{2}$ lb. of acid salt to one gallon of cold water. If desired it may be mixed with whitewash so long as it remains a 5 per cent. solution. It should be noted that this solution will attack metal and glass, and therefore should be mixed in a wooden tub ; it has no adverse effect upon wood, brick, stone, mortar or plaster. The solution should

be applied to the surfaces to be sterilised by means of a brush, and every effort should be made to ensure its penetration into all the cavities and cracks.

Very often, when decayed timbers are removed, bricks are found to be loose, and have to be taken out. They should be thoroughly cleaned of all dust and all mortar, and should be placed in a bucket of the silicofluoride, to soak for a short period before being relaid.

Tar Oil Preservatives

The properties, and consequently the specification, appropriate to a preservative that is composed of tar oils and is to be merely superficially washed or sprayed on to wood inside a house are different from those demanded by a preservative for use out-of-doors. The first property required by a preservative for outdoor use is that it shall be a powerful and durable preservative,but for indoor use an indispensable characteristic is that it shall not render a house or room uninhabitable by reason of its odour. It must therefore be free from naphthalene, evil-smelling sulphur compounds, and other highly odorous bodies. For indoor use the preservative must be sufficiently viscous and adhesive to cling to the brush and not to flow away too rapidly from a vertical wood surface. It must be devoid of danger from the point of view of fire, so that it must not give off vapours until a high temperature is attained. Finally, it must not evaporate too quickly. Thus thin oils containing a considerable percentage of the light-oils of lower boiling points are unsuitable because they adhere neither to the brush nor wood ; moreover they have a low ignition point so that, although the light oils penetrate more rapidly, this advantage is lost because it is not safe or economic to heat the preservative to a temperature sufficiently high to aid materially the penetration into the wood ; also the light oils evaporate or change rapidly and their toxic efficiency is short-lived.

One authority prescribes as a good preservative filtered anthracene oils 70 per cent., green oil (obtained from the distillation of pitch) 20 per cent., wood tar (devoid of water) 10 per cent. Others prescribe a mixture of tar oils having a specific gravity of 1·10–1·12 ; distillation not beginning below 230° C. or boiling not beginning below 200° C.

Another preservative found to be effective is a heavy tar oil with volatile distillates of the character of heavy solvent naphtha. When 100 ml. of this are taken at 38° C. the distillation should conform to :—

Specific gravity at 60° F. 1·054.
Specific gravity at 100° F. 1·037.
Distillation up to 205° C. 1 per cent. by volume.
Distillation up to 230° C. 15 per cent. by volume.
Distillation up to 315° C. 50 per cent. by volume.
Distillation up to 380° C. 87 per cent. by volume.

Residue, non-volatile, at 315° C.	51 grams.
Tar acids	7 per cent. by volume.
Tar bases	1·9 per cent. by volume.
Naphthalene and other picrate forming hydrocarbons	12·2 per cent. by volume.
Water	Trace.
Matter, insoluble in benzene (" carbon ")	0·20 per cent. by weight.

This specification contains a percentage of naphthalene, but the odour disappears after a short time, and this class of preservative is considered to be eminently suitable for indoor work.

It is not practicable to lay down any one prescription as the right one ; conditions vary, and a considerable range of mixtures may be effective. The limits of variation within which oils, the products of coal tar distillation (free of petroleum oils, but allowed to contain other toxic oils and salts) have been found in practice to be efficient *out of doors* when tested under the drastic conditions prevailing in the tropics, may be indicated as follows :—

(1) The specific gravity shall not be less than 1·015 and not more than 1·07 at 38° C.

(2) The amount of tar acids shall be not less than 5 per cent. or more than 12 per cent. by volume.

(3) The amount of water in the creosote shall not be more than 3 per cent.

(4) The amount of matter insoluble in benzol shall not exceed 0·4 per cent. by weight.

(5) When 100 ml.* measured at 38° C. of the dry creosote are distilled from a 250-ml. Wurtz flask, with an outlet from the neck approximately 6 cm. from its base and the distillation completed in about 20 minutes, there shall distil at 760 mm. pressure—

Up to 205° C. from 0 to 7 per cent.
Up to 230° C. from 10 to 40 per cent.
Up to 315° C. from 45 to 78 per cent.

(6) The material shall be completely liquid on being slowly warmed to 38° C. with stirring, and on cooling down shall remain completely liquid after standing for two hours at 32° C.

(NOTE.—The methods of determining the constituents and physical properties should be those given in the British Engineering Standards Association's Specification for creosote for the preservation of timber.)

This specification provides for the lighter creosote oils having a distillation range near the limits set out in the British Engineering Standards Specification Type A and also for heavier proprietary solutions derived from coal-tar some of which might contain small quantities of other highly toxic and very beneficial oils and salts.

The upper limit of tar acids has been fixed at 12 per cent., because from extensive experience in India, it was found that creosote containing as much as 16 per cent. (as permitted by the British Engineering Standards Specification for railway sleepers, etc.), tended to corrode spikes, screws and nails and is, therefore, unsuited for the purposes for which the creosote covered by this specification is required.

It should be realised that some of the mixtures falling within these limits may be unsuitable for internal use on account of the pungent odours. It is important, as already said, that in dwelling rooms, or near larders, mixtures having a strong odour should not be used.

Precaution in using the Heavier Tar Oil Preservatives

The heavier tar oil preservatives have certain marked characteristics :—

(*a*) They usually possess a strong pungent smell, and when such a preservative is used on the interior woodwork of a building this smell may persist for weeks, or even months.

* In this Bulletin, 1 millilitre (ml.) may be taken as equivalent to 1 cubic centimetre (c.c.).

(*b*) They are usually dark brown in colour and therefore stain all woodwork.

(*c*) It is not possible to apply oil paint over some preservatives of this type, as the preservative may "bleed" through and discolour, if not destroy, the paint.

(*d*) Oils possess considerable penetrative powers and will "creep" along the cracks or fissures of timber for considerable distances. If, for instance, the back of a panel or an ornamental timber be treated where it contains a knot, the preservative will gradually penetrate around the knot, through to the exposed side, and may cause discoloration;

(*e*) If the timber near a plaster ceiling or a plastered wall be treated, the oils will creep into the plaster and cause discoloration. To prevent this, it is advisable to protect all adjoining surfaces with sheets of paper, or waterproofing cloth. This will prevent the absorption of any excess of the liquid.

(*f*) When these preservatives are used at moderately high temperatures, fumes are given off and sometimes cause a sense of discomfort in the eyes of the workmen; there is no permanent effect, however. Heavy tar oil preservatives are highly inflammable, and whilst heating them every precaution should be taken against fire. It is advisable that the operatives, when using the hot liquid, should be protected by means of overalls and gloves.

Methods of Applying Preservatives

The method of application of the preservative to wood (or other materials) varies with the degree of protection desired and the need for economy. The simplest and cheapest method is to apply one, or preferably two, coatings to the surface by means of either a brush or a spray. In order to ensure deeper penetration, suitable preservatives should be applied hot (for instance, those derived from heavy coal tar oils at temperatures between 140° and 160° Fahr.). Some of the silicofluorides, however, easily dissociate when heated and therefore must be applied cold. The weak points in mere superficial application of the preservative are that this penetration of the wood takes place only to a slight depth, with the consequence that, through cracks caused by shrinkage or by other means, patches of wood not reached by the preservative are laid bare and the way is opened for infection, while those preservatives soluble in water are liable to be washed out by rain, running or dripping water.

In order to decrease these dangers by ensuring deeper penetration of the fungicide, pieces of wood before being installed in the house may be submerged for a time in a bath of the preservative. The temperature of the bath and duration of the submergence depend on the preservative used, the depth of penetration required, and on the nature and condition of the wood.

The most elaborate and costly treatment, and the one giving the deepest penetration and most reliable protection, is that adopted, for instance, in introducing creosote into paving blocks, railway sleepers and telegraph poles in this country, namely, injection of the preservative into the wood by means of pneumatic pressure. In this case, of course, the wood has to be treated at a works where the required injecting plant is available.

General Measures to Assist Penetration

When using preservatives on timber certain general measures are necessary in order to ensure as much penetration as possible :—

(1) Before treating old unattacked timbers which are to be retained, it is important that all dust and dirt should be removed.

(2) Timber to be treated with tar-oil preservatives should be in an air-dry condition. Tar oil preservatives cannot be used with success on wet timbers, as the moisture present in timber will prevent adequate penetration.

(3) In surface treatments, two coats of the preservative should be applied, whenever possible by means of a brush, and each coat should be thoroughly worked into the surface fibres and cracks in the timber.

Application of Tar Oil Preservatives Hot

As already stated, deeper penetration can be obtained by employing these preservatives in a heated condition at temperatures between 140° F. and 160° F. The penetration of the preservative into existing timbers is assisted by boring auger holes across the grain at convenient intervals ; particularly, close to the ends from which any defective timber may have been removed. These holes should be filled with the preservative liquid and temporarily plugged. When the liquid has soaked away, the process should be repeated, and the holes permanently filled with wood plugs. This method is especially suitable for dealing with thick timbers, which cannot be removed, and which have had decayed portions cut from them. New timber and any old timber which can be easily removed for treatment should, if practicable, be immersed horizontally in a bath of the preservative, maintained at a temperature of 140° F. to 160° F. for, say, at least 30 minutes.

Alternatively, the timber can be placed upon end in an iron boiler containing the preservative, and such a treatment would be suitable for joists which are to have one of their ends placed into a wall which has been infected or a wall from which moisture cannot be entirely excluded. Thorough penetration of the preservative into the end of the timber would thus be obtained and the remainder of the surface could be treated by means of a brush.

It is reiterated that tar oil preservatives, unless in emulsion form, do not penetrate wet timber.

Paint

The part played by paint on external woodwork is not quite simple. Properly brushed on to appropriately seasoned wood, it serves to hinder the ingress of water prevents spores from reaching the bare wood, and decreases the liability of the wood to crack through shrinkage. But when the paint is applied to inadequately seasoned wood, it may do more harm than good ; for the paint blisters, patches of wood are soon laid bare, and the wood may split as it dries and shrinks. The result is that spores, alighting on bare patches or falling into damp cracks, may germinate and find available to them wood which has been kept relatively moist by the coating of paint, so that decay may be more rapid than if the wood had not been painted.

PART III.—PRECAUTIONS TO BE TAKEN IN THE USE OF TIMBER IN NEW BUILDINGS TO PREVENT OUTBREAKS OF DRY-ROT

The Value of Timber in Building

THE intensive post-war search for substitutes for the traditional building materials has not so far shown any signs of producing a substitute for timber, the most adaptable of all the orthodox materials of construction.

Like other building materials, timber will deteriorate with time; but under normal conditions the deterioration will be no more rapid than that of many of the other materials with which it is associated and, in spite of its peculiar liability to attack by fungus and insect, its advantages maintain it as the most economical and efficient material for a large variety of building purposes.

Conditions Conducive to Decay of Timber in Buildings

It has been pointed out in Part I that while every wood may be attacked by one or more fungi, there are some fungi which prefer certain kinds of wood, some certain portions of the wood, and that all have different optimum conditions for growth; further that, in temperate climates, by far the commonest and most destructive species is *Merulius lacrymans*, which prefers the sapwood of unsound softwoods, but can attack the most durable of hardwoods. In these circumstances, it appears desirable, from the building view-point of prevention and eradication, to consider the common conditions under which all destructive fungi act rather than attempt to deal with them individually; particularly as it will always be necessary in design to provide against all species.

The salient points which emerge from a study of the mycology of the subject are:—

(1) that heat, air and moisture are necessary for the growth of all dry-rot fungi;
(2) that the fungi will not thrive when a great excess of one of these agencies is present;
(3) that, although a fungus may be killed by excessive heat, it is probable that no extreme of natural cold will kill it, although its growth may be restricted; and,
(4) speaking very generally, softwoods are more frequently attacked than hardwoods, sapwood more frequently than heartwood, and quick-growing timber more frequently than slow-growing.

Selection of Timber

When selecting or inspecting timber for construction, point (4) above must particularly be kept in mind, and the aim should be to prevent the use of any but well-seasoned timber as free as possible from sapwood or shrinkage-cracks which might afford good lodgement for spores of fungi. Wherever possible the conditions of storage should be ascertained and nothing allowed on the site which comes from a yard in which careless stacking or unclean conditions are tolerated, such as damp foundations or an accumulation of rotting waste. All timber should be rejected which shows signs of unsoundness (e.g.

timber bearing indications of disease in the living tree), as any such defect may pave the way for subsequent fungoid attack in the building. In this connexion, it should be pointed out that, while the familiar defect known as " blueing " may be without effect on the strength of wood fibres, it is possible that it may render the wood more liable to subsequent dry-rot ; in any case, " blueing " is a very clear indication of the presence of sapwood.

Precautions in Design and Construction

Heat and air (two of the three fundamental factors necessary to fungal development) are not easily brought under control. Although dry-rot often starts on timber at a high temperature, e.g. near fire-places or heating coils, the temperature of all the timber in a structure is within the optimum range for fungoid growth. As regards air, the designer cannot always provide for a strong current of fresh air reaching the remoter situations (mentioned later) where timber is unwisely, but still commonly, used ; nor can he ordinarily seal the timber against stagnant air.

Therefore, while the use of timber in such positions as the above should be avoided as much as possible, the exclusion of the third factor, moisture, assumes increased importance, so much so that it should be the designer's first consideration.

A corollary to this is the desirability of ensuring that all building timber is stored in a dry place for, say, one month prior to incorporation in a structure.

While the access of moisture is often the result of subsequent accidents to the structure, there is no doubt that a very great deal of structural timber which, on paper, at first sight appears to have adequate protection from damp, in actuality is very liable to become wet, with no opportunity to dry quickly.

The most vulnerable points of the timber in a structure are where it comes in contact with other materials of construction which are introduced into the building in a wet state, or which, although not really damp-proof and weather-proof, are employed as a protection against damp and the weather.

The comparative immunity from dry-rot enjoyed by good timber-frame construction (although often made up largely of sapwood) when kept in good repair and well insulated from ground water is probably due to the fact that no moisture penetrates beyond the outermost covering, and because the small-scantling timbers employed are well placed for rapid drying. On the other hand, the one-brick wall of many types of bricks now in common use is not in the least capable of ensuring dry conditions for wall-plates, joist-ends and other timber in contact with it ; and the same objection holds with external walls of some of the concrete blocks turned out by rapid-production processes which entirely ignore the factors making for impermeability.

Even if the bricks or blocks themselves are satisfactory, often the mortar joints are not. The 9-in. wall of any but the least porous of bricks requires a coat of roughcast or similar protection. The 11-in. cavity wall of brick is an alternative to the protected, one-brick wall, but, as a moisture bar, the efficiency of the cavity is often impaired by carelessness during erection ; for mortar droppings are often left piled up in the cavity above the damp course and on the ties, thus providing moisture bridges from the outer to the inner section of the wall.

It is possible to construct impermeable walls of poured concrete without the aid of integral or surface water-proofers. The danger points in such walls are where pouring has been temporarily suspended, and where wire shutter ties have been left in or where tie bolts have been withdrawn. The junction of poured and pre-cast concrete work is another constant source of trouble unless special precautions have been taken in design and construction.

The tendency in recent years to economise by using inferior damp courses is culpable. It is not uncommon to see a material which is known to have a very limited life incorporated in a structure as a horizontal damp course—that is to say, in such a position that any replacement when the material has deteriorated is so costly as to be usually out of the question.

The condensation of moisture on the internal surface of the walls is an evil to be avoided as well as the penetration of moisture from the ground or from the exterior; other conditions being favourable, it is quite capable of providing sufficient moisture to aid the germination of spores or the growth of fungi behind skirting boards, architraves, and the like.

The ordinary type of timber ground floor, consisting of boarding on joists, with intermediate sleeper walls and surface concrete, affords good opportunities, which are not always grasped, for obtaining proper ventilation and damp-free conditions. Air circulation is hampered by solid, instead of honeycomb, sleeper walls and by air vents being placed on one wall only. A current of air, under the floors, right through the building, should be induced by air vents of as large a size as reasonably possible, by openings in partition walls and by pipes through solid floors where these intervene (Fig. 9). The damp course is occasionally omitted in sleeper walls, and the value of the horizontal damp-proof course in walls is sometimes jeopardised by using solid concrete floors in neighbouring rooms without precautions to guard against the permeation of moisture from the made-up ground, through the intervening wall, above the damp-proof course (Fig. 10). In a water-holding subsoil a horizontal damp course in the external walls is not always sufficient, and so the percolation of moisture through the walls below the horizontal damp course and above the surface concrete must be prevented.

The spores of fungi may be present in the soil, or possibly on the timber itself, and they may even be introduced into a building with the coal or wood-fuel supply. It is therefore desirable to obtain complete insulation between timber and soil and to place air vents rather higher above ground level than is the usual practice, or to lay garden paths close up against the walls; not only the damp course, but the air vents themselves are very liable to be covered by earth thrown up to form a garden bed. Also, it will be as well to ensure that no direct communication between the coal store and the timber in floors and the like exists.

A great deal of trouble has been experienced with wood floors laid directly on concrete. The economic advantages of a ground floor of this type over one consisting of flooring on joists, plates and sleeper walls are obvious, and it is therefore particularly desirable that a serious attempt be made to mitigate the danger of rot.

The durability of the wood of these floors depends very largely on the quality of the concrete. There is no reason why this, with careful proportioning of the right materials and the proper ramming and curing conditions, should not be practically impermeable. A thinner layer of impermeable concrete (lightly reinforced if necessary) and laid on hard-core will be immeasurably superior in every respect to the 6-in. layer of roughly deposited, insufficiently rammed and badly proportioned mixture which is only too common. Not only does the necessity for impermeability apply to the concrete on which timber is to be directly laid, but where sleeper walls intervene it is still just as desirable, particularly over a water-holding sub-soil.

The actual fixing of the flooring direct to concrete is very important. Of the many methods employed, the following appear to be the safest (see illustration, Fig. 11):—

Method A. Impermeable concrete (i.e. well proportioned and with a non-porous aggregate) is laid over the site to a minimum depth of 4 in., with an upper

layer of 2 in. of clinker or breeze concrete. The surface of the breeze concrete is covered with a damp-proof membrane, and the boards are nailed through this direct to the breeze concrete.

Method B.—The boards are nailed through the damp-proof membrane direct to the breeze-fixing blocks imbedded in the impermeable concrete.

Method C.—The boards, in this case preferably grooved and tongued, are laid direct on to 2 in. of breeze or clinker concrete, a damp-proof membrane being interposed between the latter and the lower 4-in. layer of impermeable concrete.

In all the above methods all the timber is partially exposed and no buried wood-fixing fillets are used. Method C has the advantage that nails do not pierce the damp course, but, before fixing the boards, a period of at least one month, under normal weather conditions, should be allowed for the breeze concrete to give up its moisture. In all cases, the undersides of the boards should be treated with a tar-oil preparation as a precautionary measure. If in solid flooring damp and air could be *entirely* excluded from the underside of the boarding, conditions would be less favourable to decay. In methods A and B these requirements might be met in practice by nailing sound, dry boarding over a damp-resisting bituminous composition (such as is used for bedding wood-block flooring) before it has set. This bituminous coat should be thick enough to take up all irregularities in the surface of the concrete and boards ; the thin, brush-applied, bituminous coat usually employed does not preclude the possibility of air cavities, and is often faulty as a damp-proof course. Especial care is required in method B to avoid reducing too much the effective thickness of the impermeable concrete by making the thickness of the embedded breeze fixing blocks too great. Even the selected methods of solid floor construction above described are open to criticism, and the alternative of substituting for timber a linoleum or cork carpeting, cemented direct on to impermeable concrete, merits consideration.

A careful scrutiny of constructional drawings, bearing in mind the ever-present danger of the incidence of dry-rot in structural timber, will generally reveal many other situations in which conditions ideal for the germination of fungal spores or the growth of fungi are likely to develop.

The omission of throating to sills, or the weather moulds on doors exposed to driving rain, must have been the cause of very many outbreaks of dry-rot. The use of wood bricks, rough grounds, slips and plugs for fixing purposes in buildings is dying but slowly, in spite of alternative materials (e.g. breeze bricks and cellular concrete) now available ; built-in wood lintels, wall plates, beams, and joist ends are still widely used. If there is a reason outweighing all other considerations for the use of timber in such ill-ventilated situations, it is at least incumbent upon the user to provide additional resistance to decay at very little extra cost by carefully selecting the timber for the purpose and previously treating it with a preservative.

Care should always be taken to remove shavings, soil, and débris from surface concrete ; also pieces of wood employed during excavation, and wooden forms for concrete work.

The danger of using linoleum over wood flooring, especially when this is laid direct to concrete, is now more generally appreciated, and on many new housing estates the use of such coverings is banned for twelve months until the houses have had time to dry out. At any time the use of a covering over the whole floor area which prevents the access of air and requires washing (with the attendant risk of moisture collecting between covering and floor) is objectionable so far as the health of the wood is concerned. The use of a jointless square of floor covering, leaving an uncovered surround, is much preferable.

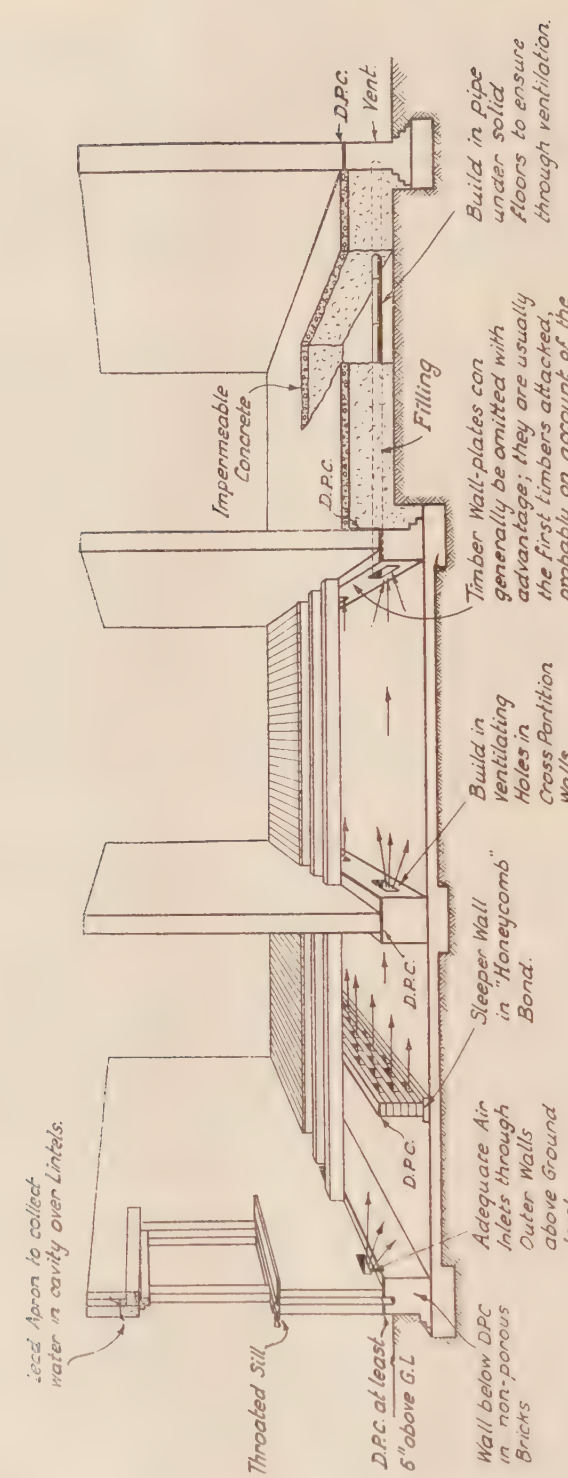

Lead Apron to collect water in cavity over Lintels.
Throated Sill
D.P.C. at least 6" above G.L
Wall below D.P.C in non-porous Bricks
Adequate Air Inlets through Outer Walls above Ground Level.
D.P.C.
Sleeper Wall in "Honeycomb" Bond.
Build in ventilating Holes in Cross Partition Walls.
Impermeable Concrete
D.P.C.
Filling
Timber Wall-plates can generally be omitted with advantage; they are usually the first timbers attacked, probably on account of the high proportion of surface area unventilated
D.P.C.
Vent.
Build in pipe under solid floors to ensure through ventilation.

FIG. 9.—*Precautions to ensure air stream through buildings below floors.*

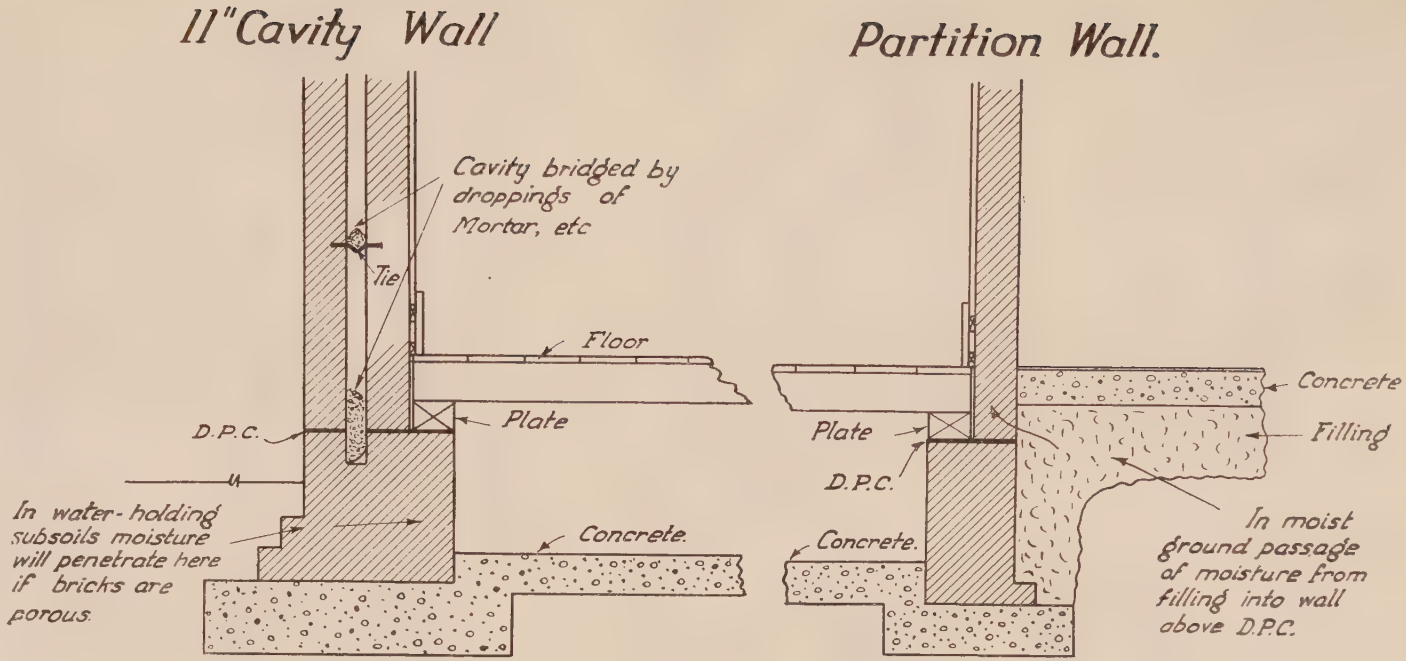
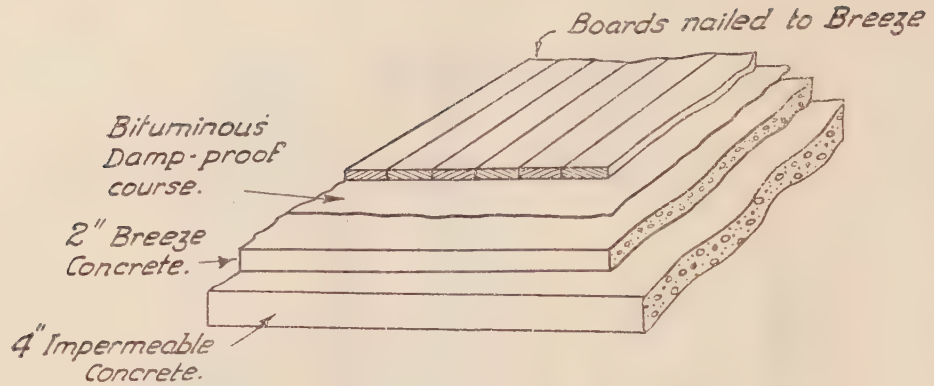
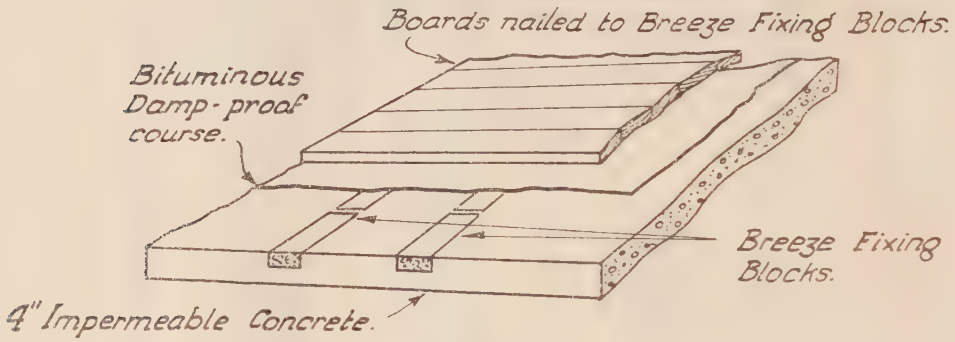


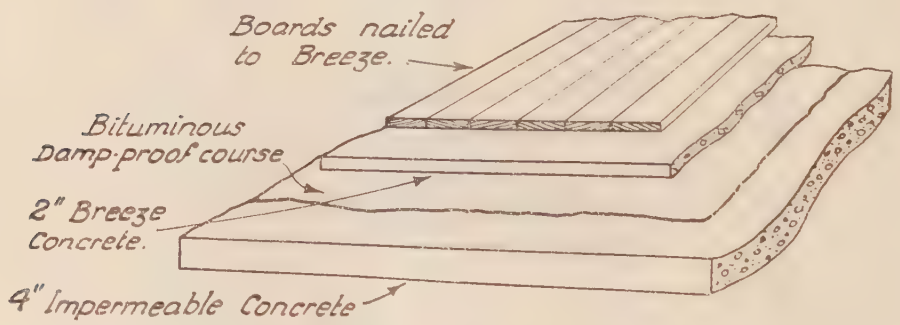
FIG. 10.—*Danger with normal types of construction.*



Method A



Method B



Method C

FIG. 11.—*Types of solid floors.*

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